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READING COURSE IN ECONOMIC ENTOMOLOGY.

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(The work of the Experiment Station is generally quite distinct from that of the Department of University Extension in Agriculture, but in this instance it seemed wise to issue a joint publication. It concerns primarily the work of the latter department, but is also intended for the training and direction of a set of reliable volunteer observers through whom the Station may expect to secure valuable data not otherwise easily obtainable.)

The desire has been very widely expressed for individual or class instruction along agricultural lines by those unable to attend the University. One of the topics upon which inquiry has been particularly made is that of Economic Entomology. We have decided, therefore, to offer a reading course in this subject calculated to give the student a broad general knowledge of the facts of the science, and an acquaintance with the most recent publications of the working economic entomologists of the country.

GENERAL DIRECTIONS.

Those desiring to enroll as readers should make application to W. T. Clarke, Assistant Superintendent, University Extension in Agriculture, Berkeley, California. Each reader will be furnished with a set of bulletins which will serve as text-book. He will be expected to make himself thoroughly familiar with their contents. A circulating library is also provided, for collateral reading and reference. These books should be read as carefully as possible in accordance with the directions given in this circular. After the completion of the work here outlined, an examination will be arranged for with an instructor in the Entomological Department.

Those who thus complete this course will be eligible to advanced standing in Economic Entomology should they subsequently enter the University. This course may, therefore, be considered a University course given *in absentia*, and must be pursued with the same care and thoroughness as though done in the class-rooms at Berkeley. The names of those completing this course will be kept as a special mailing

list, and they will receive thereafter not only the bulletins of the Experiment Station, but also all circulars and notices of special publications of the Entomological Department.

Those reading in this course by themselves will receive the books forming the reference library, one at a time by express, and will be required to pay the express charges both ways. There will be no fees or other charges to be paid by the student, except for damage to books beyond reasonable wear. The Entomological Department will attempt to answer letters of inquiry of readers in this course, and to assist them in any difficulties they may find in their studies.

Reading Circle.—It is strongly recommended that wherever possible a reading circle be formed for mutual helpfulness in this study. Where this is done, the whole reference library will be sent to the member designated by the circle, and the distribution can be arranged to suit the convenience of the members. We would suggest that the circle form an organization, charging a sum for membership sufficient to raise a fund not only to pay the express charges on the circulating library, but also to buy a few books on the subject for the local library or as a nucleus for a public library, if one is not already in existence in the community. Thus the work of the circle will become more permanent.

Another advantage of the organization of a reading circle will be the possibility of personal instruction by a visit, to the community, of a member of the staff of the Entomological Department. Where possible some such arrangement as the following will be made: After the completion of the course by a circle a date will be arranged for this visit. The instructor will spend half a day with the members of the class, visiting orchards and studying the insect pests out of doors. Another half day will be spent with those who have followed the course, in answering questions and discussing difficulties met with by members of the class, and in holding the examination. The evening may be devoted to a public lecture, where a topic of general interest will be discussed.

WHY STUDY THIS SUBJECT.

The study of Economic Entomology appeals more or less strongly to a large number of people and is valuable for two important reasons: its educational value and its economic value.

Educational Value.—The importance of the educational value of this study may be overlooked at first sight by the practical grower, but he will be none the less ready to acknowledge its claim when it is clearly seen. What is meant by the educational value of a study is the development of power that arises from it. If one can become more able to observe clearly, to quickly comprehend the significance of what he sees in the practical problem he has in hand, and learns how to direct his

observations so that he will obtain the facts needed for the solution of his problem, these are qualities of high educational value whose importance no one can question. Economic Entomology is full of problems of every degree of difficulty inviting the student ever onward. It will be attractive, therefore, to many primarily from the motive of its educational value, and this motive should influence—indeed, largely shape the method of study of every student. Do not study for “general information,” making the mind simply a warehouse for the storing of miscellaneous facts to no definite purpose, but seek for power to know, to select, and to use facts.

Economic Value.—Most persons are well aware that the economic importance of insects is enormous, and look to Economic Entomology for a relief from their ravages. Some confuse Entomology with Economic Entomology, and have lost sight of the fact that the latter is a department of economics and has to deal primarily with questions of money values. Whenever the quality or quantity of an agricultural product is diminished by the presence or activities of insects, it is only in such cases that we have a problem in Economic Entomology.

The solution of the problems of this science consists in finding ways and means of avoiding some of the losses due to insects, with, at the same time, a relatively small expenditure, the index of the success being the amount of money constituting the difference between cost and saving secured.

Strive to keep these facts always in mind, endeavoring to develop sound judgment as to the money value of that destroyed by insects, and the degree of probability of loss by their future attacks.

HOW TO STUDY.

In this reading course the error one will be most liable to make is to fail to connect what he reads with his own experience. Every one has had more or less acquaintance with insects and their work. If one fails to recognize each of his old acquaintances as he reads about them he misses by just so much the purpose of this study. The reader should ask himself as each insect is discussed, “Where have I met this creature?” And as each fact is brought forth, the further question should be, “Was this my experience?” Reading in this way, that which would otherwise be dry and meaningless becomes full of interest.

Further than this the student should begin to observe insects more earnestly than ever before. Every statement one finds in the books that he can readily verify he should strive to determine for himself. Every insect in the field holds something of value to be discovered by the earnest student. Let one’s reading become a key to nature, for it is nothing apart from nature.

In an attempt to study insects in connection with the reading, the

greatest difficulty that will be met with is the small size of the creatures studied. A great deal can be learned, even about the smallest forms, with the unaided eye; but the use of a good hand magnifier will open up a new world to the student.

How to Select a Magnifier.—Do not choose a lens of large size. The magnifying power is generally greater the smaller the size of the lens. For the work proposed in this course we would recommend a $\frac{3}{4}$ -inch Coddington lens. This can be obtained through any dealer in optical goods. In choosing a lens the student should know that freedom from aberration is the quality most to be sought after. Aberration is of two kinds, chromatic and spherical.

Chromatic aberration may be detected by first putting the lens very close to a printed page and slowly withdrawing it. As the letters begin to lose their distinctness more or less color will be seen around them. A lens should be rejected if these rainbow colors are very pronounced.

Spherical aberration may be seen when the lens is removed still farther from the paper, when the letters will appear distinct again, but small and upside down. Now if the lines are straight and not closer together at the edges the lens is of good quality in this respect.

How to Use a Magnifier.—After one has obtained a lens he will have to use it the right way to get the best results. The most important thing is to see that the point at which one desires to look is in the light. One must not allow the head or the lens to throw a shadow on the object and then expect to see plainly.

The next most important thing is to hold all steady. The best plan is to lay the two hands against each other, one holding the object and the other the lens, and bring the cheek against the hand, with the eye as close to the lens as possible.

LIFE HISTORIES OF INSECTS.

Next in importance to the obtaining of that familiarity with the structure of insects that will enable us to recognize any particular kind, is an acquaintance with the facts of its growth and development and with the relation it bears to the season.

Moulting—The most important fact in the structure of an insect is the hardening of the skin to serve as its skeleton. This makes necessary the process known as moulting, whereby the hardened outer skin is cast off, so as to permit the enlargement of the body to meet the necessities of growth. All insects go through this process a number of times before they become full grown. The detail of the process varies greatly among the different insects, and may be very different in the earlier and later moults. If the student has not already observed the process he should cage a caterpillar in a tumbler, or other convenient

receptacle, providing it with fresh food and keeping it under observation until a moult occurs. The approach of the moulting period may be known by the insect refusing food.

Practically all the changes in structure or in the size of the hard parts of the body are brought about at the time of the moult, and the change is, therefore, sudden. The most important moult is usually the last one, for at this time the wings and other adult structures are perfected.

Metamorphosis.—The change that occurs during the life of an insect, through its various moults, is called its metamorphosis. We can distinguish three types of metamorphosis:

1. *Primitive*, in which the change at each moult is only moderate in amount.

2. *Simple*, where the change at the last moult has come to be much more profound than at any of the others, on account of the development of wings. This is often called incomplete metamorphosis, though the term simple is much more satisfactory.

3. *Complex*; two moults being required to accomplish the change from the young to the adult condition, the stage between these two moults is entirely occupied in accomplishing the reorganization of structure, and the insect is incapable of taking food during this interval. The term complete metamorphosis is often applied to this type of transformation.

The periods of life of an insect are designated as follows:

With Primitive Metamorphosis: egg	insect		
With Simple Metamorphosis: egg	nymph		imago
With Complex Metamorphosis: egg	larva	pupa	imago

Annual History.—The possession of metamorphosis permits insects to adapt themselves so well to the changing conditions of the seasons that it may be that the seasons are largely responsible for the development of this course of life. At any rate, the annual history of an insect, by which we mean the condition of development of the insect during the different portions of the year, is the most important study to be made preliminary to the mapping out of a plan of campaign against it. How important this matter is may be seen by carefully reading the account of the vine hopper, the potato worm, the peach worm, and the codling moth, or of almost any of the injurious insects.

In one's reading and in his study of insects in the field the first work should be to get a clear idea of the annual history of the insect under consideration. A good plan is to construct a diagram something like that given for the peach worm.*

*Bulletin No. 144, p. 32.

Careful observation in the field during one year should be sufficient to gain a fairly complete annual history of an insect, unless it presents peculiar difficulties. Sometimes it is rather difficult to follow an insect at a particular season. Some plant lice, for instance, at the period of migration experience a great mortality, and from excessive abundance may in a week become so scarce that a very careful search fails to reveal them anywhere. Perhaps the next spring they may reappear in an equally mysterious manner and increase to excessive numbers again by fall.

Possibly some of these cases would become less mysterious if we made use of cages to confine some of the insects so as to watch the development so closely that we would with certainty recognize the insect in all its stages. This is almost essential in the case of insects with complex metamorphosis, since the change from larva to pupa and from pupa to imago is so great that one can not safely connect the different stages of the same insect without positive proof.

Any kind of tight receptacle will do for a breeding cage to make these determinations. Glassware, such as tumblers or lamp chimneys, will be found very satisfactory for this purpose. Food should be kept fresh and all the conditions maintained as normal as possible.

CLASSIFICATION OF INSECTS.

The student should make himself acquainted with the classification of insects, so that he may intelligently follow the literature of entomology, and because the insects belonging to a particular group have a blood relationship with each other, and the knowledge gained about one member of a group will be full of suggestions to the student when he attempts to master another.

Insect Names.—For the purpose of accurately designating insects a system of technical names has been adopted by naturalists. The full technical name of an insect consists of three parts: (1) the *genus* name, which is usually derived from a Greek substantive, and always begins with a capital letter; (2) the *species* name, usually a Latin adjective corresponding in gender with the genus name, and beginning with a small letter*; and (3) the *authority*, an abbreviation of the name of the original describer of the insect.

Thus one of our commonest grasshoppers bears the name *Ædaleonotus enigma* Scud., which might be translated into English as Scudder's puzzling Swollen-back.

*A common usage is to capitalize those specific names which have been derived from proper names, but the rule of never capitalizing specific names, as adopted in this circular, is preferable.

Synonyms.—Unfortunately, many insects have received a number of names. The rule has been established that the first specific name given to an insect, if it does not already belong to another of the same genus, should always be retained as its true name. Often, however, some one else may give it another name, either because he did not know of the first name or because he thought he had a different insect. The new name, of course, can not hold, even though it may have come into general use.

Another source of synonyms is the placing of the species name with the wrong genus name. All the species in a genus should be very closely related with one another, and if a species is placed where it really does not belong it must be changed.

Group Names.—A scheme has become generally adopted of indicating the groups of insects by using a genus name with a special termination; thus,

Genus, *Acridium*.
Tribe, *Acridiini*.
Subfamily, *Acridiinae*.
Family, *Acrididae*.

There are several other group-terminations that will be occasionally met with, but which are not as yet generally adopted.

Orders of Insects.—The primary division of insects is into Orders. The names of the orders were given before any one had the idea of using derivative group names. The names of the principal orders end in *-ptera*, meaning wing, because Linnæus, who gave these names, separated the orders by peculiarities of their wings.

There is much difference of opinion as to how many orders should be recognized. These differences of opinion are entirely in reference to the smaller groups. All are practically agreed about the greater orders. The six large orders are:

Orthoptera = Grasshoppers, etc.
Hemiptera = Bugs, plant lice, scale insects, etc.
Coleoptera = Beetles.
Diptera = Flies.
Hymenoptera = Wasps and bees.
Lepidoptera = Butterflies and moths.

The student should get these six groups thoroughly well fixed in his mind, so that he can recognize a figure or a specimen of the adult insect. The structure of the mouth-parts and of the wings should receive attention. He should also understand about the metamorphosis of each group and recognize the young insect.

The minor groups consist of: ·

Aptera. Minute wingless insects, now generally recognized as forming a distinct order; none are of much economic significance.

Odonata, the dragon flies and damsel flies, aquatic as nymphs and predaceous throughout their life. Often counted a distinct order, but sometimes united with other aquatic insects.

Ephemera, May flies; aquatic forms, which are short-lived and do not take food as adults. None are of economic importance. Often counted a distinct order, but sometimes united with other aquatic insects.

Plecoptera, the family *Perlida*, aquatic insects of no economic importance; are sometimes counted a distinct order.

Forficulida. The earwigs usually placed with the Orthoptera, but sometimes separated by themselves; have subterranean habits and are of but little economic importance.

Isopoda. The family *Termitida*, the white ants, is very injurious in the tropics, but rare in the temperate zone. The group is commonly united with the following.

Corrodentia. The family *Psocida*, including only insects of no economic importance, is often considered a distinct order.

Mallophaga. The bird lice are very commonly considered a distinct order, but are in reality quite close to *Psocida*, and might be included in the former group.

Physopoda. These minute insects are the true thrips, and are often highly injurious to cultivated plants. They are very commonly counted as a distinct order, but are certainly allied to the Hemiptera and are often included among them. A few authors place them in the Neuroptera, which is made to include all insects not in the six major orders.

Pediculida. The true lice have usually been grouped with the Hemiptera, with which they are certainly closely allied; but some authors have united them with the Mallophaga, and others have made them an order by themselves.

Sialida. This group of aquatic insects is sometimes made an order by itself and very generally separated from the *Perlida*, on account of having complex metamorphosis, though in other particulars it is closely related. The group is not economically important.

Panorpida and *Hemerobiida*. These families of terrestrial insects have been made an order by some entomologists, though commonly classed with the former group, to which they are near allies. None are injurious; a few may be of some value, on account of their predaceous habits.

Phryganeida. The caddice flies are aquatic insects forming a group which has been given rank as an order by several entomologists, but is often grouped with the preceding. They are of no economic significance.

Pulicida. The fleas have been made a distinct order by some, though they are closely allied with the Diptera and classed in that order by most authors.

In the above list the various names which have been assigned to these minor groups have not been given, but the family names will enable one to recognize the group in every case.

It will be noticed that the *Physopoda* are the only insects in this list which are of any considerable economic importance in California, and this group can be classed with the Hemiptera. The six larger groups, therefore, are all we need to seriously study in Economic Entomology.

INSECTS OF CALIFORNIA.

There are more insects known to occur in California than have been listed in any other State. The great majority of these are of little or no economic significance. The really troublesome forms do not form a very large list. The student should endeavor to gain some knowledge of all of these. As a guide in this matter the following enumeration of injurious forms is given:

ORTHOPTERA.

The insects in this group are mostly vegetable-feeding forms and are general feeders; that is, none of the species confine their attacks to a particular plant, as is so common with the higher insects. A fairly complete account of the more injurious members of the order is given in Bulletin No. 142; some of the less important forms are discussed in the reference books. The injury these insects do to plants is so evident that it is comparatively easy to estimate the amount of loss resulting from their attacks. One family, the *Mantidæ*, is predaceous and has figured to some extent in the schemes of introducing beneficial insects to attack injurious ones.

HEMIPTERA.

The interest in this group centers mainly around the scale insects and plant lice, though most of the members of the order are also plant feeders and several forms are highly injurious. A few bugs are predaceous, but have attracted very little attention.

All the vegetable-feeding forms obtain their food by sucking the juices of plants, and it is very difficult to determine in any particular case the exact amount of injury to be expected to result from an attack. Up to a certain point the presence of a sap-sucking insect amounts to nothing, and when the general vigor of a plant is good and the conditions otherwise favorable, a plant can stand without appreciable injury what would in other cases be fatal to it.

One must take into consideration the moisture condition of a plant as well as the numbers of the insect present.

Another factor which complicates the problem is the sporadic increase and decrease of these insects which is often noticed. Many of them are capable of increasing with incredible rapidity when conditions are favorable. Since we do not know exactly what these conditions are it is hard to say whether the insect in question will reach injurious numbers or not. Again, under other equally unknown conditions not only the fecundity may suddenly diminish, but the life of a greater part of the individuals may be lost and the whole economic situation be changed. The student should observe with greatest care the evidences of changes of this kind, and may be able to add materially to the knowledge of the subject. At any rate, he should get enough acquaintance with these phenomena to cause him to exercise due care in coming to conclusions in regard to the action of insecticides or of any other means of control that may be adopted. A very good experiment which will show the effect of external conditions upon these insects may be made by covering the top and three sides of an apple tree with mosquito netting and comparing effect on the woolly aphis as contrasted with adjacent trees in the orchard.

Physopoda. Some of the reference books give a very good general account of these insects, but there has been very little done experimentally toward their control. Those favorably located for making observations on the life history of these insects, especially their wintering habits, or on the application of insecticides, can make real additions to our knowledge of the subject.

Coccidæ, or scale insects, have done a great deal of injury in this State, and the San José scale is one of the best known injurious insects in the United States. The reference books give a particularly full account of this insect and of experimental work for its control. This subject deserves very careful study. Besides the San José scale (*Aspidiotus perniciosus* Coms.) we have in California the closely allied greedy scale (*A. rapax* Coms.) and the oleander scale (*A. hedrea* Vall.), with much the same habits, but hardly as injurious, and also the red scale (*Chrysomphalus aurantii* Mask.) of the orange. The long scales, the oyster-shell scale (*Lepidosaphes ulmi* Linn.) of the apple and the purple scale (*L. beckii* Newm.) of the orange, are really also quite similar in habits to the above.

Another kind of scale is represented by the black scale (*Saisetia oleæ* Bern.), the soft brown scale (*S. hesperidum* Linn.), the brown apricot scale (*Eulecanium armeniicum* Craw), and the pruinose scale (*E. pruinatum* Coq.). They are rather better protected from sprays when full grown and more easily killed when young than the scale insects formerly enumerated. The development of the smut fungus in the excreta of these insects gives them additional means of doing injury to fruits and ornamental plants.

The cottony cushion scale (*Icerya purchasi* Mask.), which is usually controlled by the imported ladybird, *Vedalia cardinalis*, forms a group quite by itself.

Aleurodidæ, or white flies, are of interest chiefly because of the possibility of the introduction of the injurious orange species of Florida, as none of the local species are particularly injurious. One of the greenhouse species is discussed quite fully in the reference books.

Aphidæ. Plant lice are next to the scale insects in the amount of injury produced. Each of the important species presents problems peculiar to itself, and the Eastern accounts of these insects will often not apply to the same species on this Coast.

The grape phylloxera (*Phylloxera vastatrix* Pla.) is the only species discussed in the bulletins of this Station, and is the most injurious insect of this group in the State. The woolly aphis (*Schizoneura lanigera* Haus.) stands next to the codling-moth as the most injurious apple insect. It is entirely different from the phylloxera in habits and character of injury, but like the latter is best controlled by the use of resistant roots.

Other important species are the hop aphid (*Phorodon humuli* Sch.), the grain aphid (*Nectarophora avenæ* Fabr.), the cabbage aphid (*Aphis brassicæ* Linn.), and the black peach aphid (*Aphis persicæ niger* Sm.). These will be found discussed from an Eastern standpoint in the reference books.

Cicadina indicates a number of families of mostly minor importance, but in the family *Jassidæ*, the leaf hoppers, there are a considerable number of important forms. They mostly attack grasses. Two species have done injury to grapevines in this State, one of which, the vine hopper (*Typhlocyba comes* Say.), is very troublesome. It is discussed in Bulletin No. 116.

Heteroptera includes the greater part of the larger members of the order. There are several families represented, including all the predaceous forms, several of which became famous a few years ago under the name "kissing bugs." There is only one member of this series of families that may be considered an injurious insect of first class, producing millions of dollars of loss in a single year. It is the chinch bug (*Blissus leucopterus* Say.), and will be found fully discussed in the reference books. This is an interesting case for the economic entomologist, because while it has been known on this Coast for years it has never done any damage, so far as can be learned.

We have several injurious species belonging to this group, but the only ones to attract much attention are the Harlequin cabbage bug (*Murgantia histrionica* Hahn.) and the squash bug (*Anasa tristis* Del.).

COLEOPTERA.

The beetles include nearly half of the known insects, but there is no large number of injurious species. The habits of the different members of the order are very diverse and must be considered group by group.

The *Clavicornia* include a large number of families of beetles, most of which feed on decaying substances. None of the California representatives are known to injure growing plants except some of the ladybirds (*Coccinellidæ*), and these only occasionally and to a slight extent. The usual food of the ladybirds consists of plant lice and scale insects, and are considered the most beneficial members of the entire order. Some *Clavicornia* are very troublesome pests in the house because of their feeding on furs, woolens, etc., and one species (*Sylvanus surinamensis* Linn.) does injury to stored grain and to dried fruits.

The *Phytophaga* are all vegetable feeders. The family *Bruchidæ* includes the pea weevil (*Bruchus pisorum* Linn.) and the bean weevil (*B. obtectus* Say.), both of which are injurious in this State as in the East. The family *Chrysomelidæ* contains the flea beetles, various species of *Phyllotreta*, *Epitrix*, and *Halitica*, and the notorious *Diabrotica soror* Lec. Many other species are occasionally locally troublesome.

The wood borers (*Cerambycidae*) are abundant in some parts of the State, and injurious to forest and shade trees; but only one—the large *Prionus californicus* Mots.—has attracted much attention as attacking fruit trees, and this only locally.

Rhynchophora, or snout beetles, are well represented on this Coast, and though they are practically all plant feeders, scarcely any have attracted the attention of horticulturists. Two closely allied species, *Calandra granaria* Linn. and *C. oryzae* Linn., the grain weevils, are well known by their work in stored grain. Several species of the family *Scalytidæ* have done very destructive work on forest and shade trees.

Serricornia include a rather heterogeneous series of families. The wireworms (*Elateridæ*) are occasionally destructive to the roots of truck crops, but what species are accountable for the damage has not been ascertained. Of the *Buprestidæ*, the “flat-headed” borer (*Chrysobothris femorata* Fab.) easily takes first place. It deserves a great deal of careful study, since the Eastern recommendations do not appear to suffice in this State. This and other species sometimes do considerable damage to forest and shade trees. Several of the *Lampyridæ* feed on plant lice, and none of the family are injurious. The only other serricorn beetle to come into prominence is one of the *Ptinidæ*, *Polycæon confertus* Lec., which bores holes into olive twigs. The larvæ feed within the stumps of grapevines.

Heteromera are unusually well represented in California, but with comparatively few injurious forms, practically all of which belong to the family *Meloidæ*. These are known as blister beetles. They are only occasionally present in destructive numbers.

Lamellicornia include a number of mildly injurious insects. The adult of several species of *Serica* and *Hoplia* have attracted considerable attention by eating the leaves and buds of fruit trees.

Adephaga are practically all predaceous.

DIPTERA.

The flies are probably the least studied of the larger orders. Many of the species are very minute, and the great majority live on decaying vegetable matter and have no economic significance.

The *Cecidomyidæ* include the Hessian fly (*Cecidomyia destructor* Say.) that sometimes does some injury to grain in the Bay region, but is far from being the pest it is in the Eastern States.

The *Tipulidæ* contain a few species that occasionally give some concern to truck farmers. The larvæ are called leather-jackets, and sometimes injure the roots of plants. Which species are concerned has not been determined. Several families contain blood-sucking species. Some are predaceous and others parasitic.

There are numerous fruit flies in other countries which may ultimately reach here and revive the interest in this order.

HYMENOPTERA.

The most important group in this order is that including the saw-flies. Two species are well known to fruit-growers: the slug of the cherry and pear (*Eriocampa cerasi* Peck.) and the green caterpillar of the pear (*Gymnonychnus californicus* Marl.), the latter being peculiar to this State, but having much the same habits as the other, which is found all over the United States.

The horntails (*Siricina*) and the gall wasps (*Cynipina*) attack mainly forest and ornamental trees, but are rarely injurious.

The joint worm of wheat (*Isosoma tritici* Riley) occasionally does a little damage. The family to which it belongs, and all the related forms, are parasitic.

Some of the wasps and the honey bee are troublesome on ripe fruit and on the drying grounds, and the honey bee is charged with systematically spreading the dreaded pear blight.

LEPIDOPTERA.

The larvæ of Lepidoptera are almost exclusively plant feeders, and include a large part of the injurious species attacking cultivated plants. They are nearly all controllable by the use of arsenical sprays, so that we may say that on the whole they are better controlled than most other pests.

Tineina include a large number of small moths, a few of which are troublesome in the house; such as the clothes moth (*Tinea pellionella* Linn.), the Mediterranean flour moth (*Ephestia kuehniella* Zell.), and a number of others. Those most injurious to plants are the peach worm (*Anarsia lineatella* Zell.), the potato worm (*Phthorimæa operculella* Zell.), the codling moth (*Carpocapsa pomonella* Linn.), and the peach-tree borer (*Sanninoidea opalescens* Edw.), all of which are discussed in the bulletins of this Station.

Bombycina average larger than the moths of the preceding group, and include over half of the members of the order. One of the larger families of this group is the *Geometridæ*. The larvæ of these moths walk by "looping," and are often called inchworms. The most injurious member of the family is the cankerworm (*Paleacrita vernata* Peck.). The *Noctuidæ* is the largest family of moths. Many species are highly injurious, especially the groups known as cutworms. There are quite a number of species representing several genera. Only in a comparatively few cases have our species been bred to the adult condition so that they could be determined. Therefore, we do not know how many species are really involved.

The *Saturnina* are our largest moths, but do not include any that are highly injurious.

The *Sphingina*, or hawk moths, include the tomato or tobacco worm

(*Phlegethontius sexta* John.), and the so-called armyworm of the grape (*Pholus achemon* Drury).

The *Rhopalocera*, or butterflies, are not generally injurious; the cabbage butterfly (*Pontia rapæ* Linn.) being an exception.

ACARINA.

Besides the true insects, this class of animals, more nearly allied to the spider, is usually considered to belong to the domain of the economic entomologist. They are all very minute creatures, appropriately called mites; some of which attack plants and produce injury much like that produced by insects.

Phytopti are excessively small creatures, and include the rust mites of the orange (*Phytoptus* sp.), the erinose of the vine (*Phytoptus vitis* Land), and the blister mite of the pear (*Phytoptus pyri* Nal.), all strikingly different from each other in the appearance of the affection they produce on the plant they infest.

*Tetranych*i, or red spiders, are still more injurious. There are various species of *Tetranychus* and *Bryobia*, usually confused with each other. One species of each of these genera is discussed in the bulletins of this Station. Much remains to be done before the other species are as well known.

INSECT CONTROL.

The means that may be adopted for the prevention of injuries due to insect attack require as careful study as the insects themselves. The student should observe with the greatest care the action of insecticides, and in every experiment arrange checks, that is, untreated trees or branches, where every condition will be comparable with the treated trees.

Many valueless materials are sold as insecticides, and the dealers are able to obtain an unlimited number of testimonials from honest men setting forth the effectiveness of their nostrum. The importance of caution and scientific accuracy in observations of this kind can not be too strongly insisted upon.

Diseases.—Attention has already been called to the great oscillations experienced by some species of insects. In many cases the cause of this can be quite definitely laid to the effect of fungous or bacterial diseases. Many have speculated upon the possibility of using these diseases for the control of injurious insects, and in a few cases considerable progress has been made. In the case of the chinch bug, for instance, an insect for which no ordinary insecticide is available, there have been notable cases of the most complete success with this method. It is considered a thoroughly unreliable method, however, because suc-

cess depends entirely upon the occurrence of favorable atmospheric conditions, which are entirely beyond our control. When these conditions occur the diseases commonly appear spontaneously without our assistance.

For these reasons, very little attention is now being given to this subject.

Parasitic and Predaceous Insects.—A method of control which has always been looked upon with a great deal of hope is that of using the natural insect enemies of the injurious species. From the earliest beginnings of economic entomology, much attention has been given to the study of parasites and predaceous insects. Various methods of favoring these insect allies have been proposed and tried, with no very flattering results until a large number of Australian insects collected by Messrs. Koebele and Webster were introduced into the State in the hope that something might be done to aid in the fight against the cottony cushion scale. One of these, a ladybird (*Vedalia cardinalis*), more than fulfilled the expectations of those concerned in its introduction. This success resulted in greatly extended efforts along this line. Mr. Koebele and our State Board of Horticulture have been untiring in their work in this direction, and while no such success as that with the *Vedalia* has followed their efforts, still the work is one deserving much more attention than has yet been given to it.

From the nature of the problems involved, it can not be undertaken profitably by individuals, but requires the expenditure of a great deal of money.

There has been much very unreliable matter printed concerning this subject, and the most extravagant statements have been made concerning insects of very ordinary degree of effectiveness. It requires the most careful and painstaking observations before any one is competent to speak intelligently in reference to the effectiveness of an introduced insect.

Resistants.—A third method of combating insects, which is looked upon with a great deal of expectancy, is the selection or development of plants upon which insects can not or will not feed. Every one has noticed plants distasteful to insects and which remained untouched while those all around have been injured by them. In two notable instances this has been made use of with the best of results. We are only at the beginning of work along this line and can only guess what may be brought forth by careful and systematic investigations.

Remedies.—While the preceding control-methods may wisely receive the attention of those in position to study them, that with which the individual grower can most profitably concern himself is the use of

chemical insecticides. This subject, however, need not be discussed in the present circular, since it is so fully treated in Circular No. 7 of this Station.

CONCLUDING REMARKS.

The purposes of this course will be largely fulfilled when the student obtains sufficient acquaintance with the facts, and such an appreciation of the difficulties of accurate observation that he shall approach a problem with such a scientific, conservative spirit that he will not be misled by appearances, unsupported by definitely ascertained facts. Whether or not this will be accomplished depends, in a reading course, upon the individual reader; since he will not have the assistance of the teacher's personal contact. This may be partly compensated for, if one is a member of a reading circle, by discussions with the other members of the circle. Not a little help will come from trying to put one's impressions into writing. For this purpose the following set of questions is given with the suggestion that each reader carefully write out answers to each question, following his reading on each subject. A comparison of the answers written out by different members of the circle will be profitable. This set of questions is the one used in the Course on Economic Entomology at Berkeley, last term. They were placed in the hands of the students just before the examination and the questions actually given were chosen by lot from this list:

QUESTIONS FOR COURSE IN ENTOMOLOGY—AGR. 7b.

Scale Insects.—(1) Give scientific names of the black scale, and explain construction of such names. (2) Describe structure of black scale. (3) Describe mouth parts, and explain manner of feeding. (4) How are scale insects distributed from plant to plant. (5) Point out the difference in structure between black and San José scales. (6) Give a general account of distillate spraying; (7) of resin soap, and lime, salt, and sulfur mixtures; (8) of cyanide fumigation. (9) Discuss the use of parasites and predaceous insects as a means of control.

Other Hemiptera.—(10) Give a general account of the woolly aphid; (11) of the phylloxera; (12) of the use of resistant roots. (13) Give method of control of leaf-inhabiting plant lice. (14) Describe injury done by the vine hopper. (15) Give its life history. (16) Explain difficulties in killing it.

Fruit Worms.—(17) Describe egg-laying habits of codling-moth. (18) Process of hatching and entering the apple. (19) Describe the pupation. (20) Discuss the use of bands for codling-moth. (21) The method of spraying with paris green. (22) Give winter habits of the peach worm. (23) Explain theory of spring treatment with lime, salt, and sulfur. (24) Describe summer treatment for peach worm.

Other Lepidoptera.—(25) Give life history of the peach-tree borer. (26) Discuss the gumming of the peach trees. (27) Describe the digging-out process of treatment. (28) Discuss precautions in the use of carbon bisulfid. (29) Give general account of cutworms. (30) Discuss the remedies for cutworms. (31) Give the remedies for cankerworms.

Grasshoppers.—(32) What is meant by the breeding-ground of migratory grasshoppers? (33) Distinguish between the migratory and non-migratory grasshoppers. (34) What remedies are available on the breeding-grounds? (35) Describe the construction and use of the hopper-doser. (36) Give an account of the use of poisoned bait for grasshoppers.

Hymenoptera and Diptera.—(37) Give the life history of a sawfly. (38) Explain method of treatment. (39) Describe life history of Hessian fly. (40) Methods of preventing its injury. (41) Describe the life history of fruit maggots; (42) of leather-jackets.

Coleoptera.—(43) Discuss means of control of white grubs; (44) of wireworms; (45) of borers.

Mites.—(46) Give the life history of the almond mite; (47) of the red spider of citrus trees. (48) Explain the effect of sulfur sprays.

INSTRUCTION IN ENTOMOLOGY AT BERKELEY.

For the information of those who desire to continue their studies in Entomology at the University, the following statement of the work offered in this department in the Summer Session, Short Course, and Regular Session, respectively, is appended:

In the SUMMER SESSION, July to August, the following work is designed primarily for teachers of nature study in secondary schools:

1. *Indoor Nature Work*. Lectures and demonstrations illustrating the study of insects in the class-room.

2. *Important Insects*. Lectures upon those insects which most conspicuously affect the interests of man.

3. *Outdoor Nature Work*. A series of excursions for the study of insects in the field.

4. *Classification of Insects*. This course is designed to acquaint the student with the methods of finding the names of insects and to acquaint him with the literature of the subject.

5. *Methods of Microscopical Study*. Designed particularly for advanced students or those owning their own microscopes; a drill in the method of mounting and microscopical observations.

The SHORT COURSE IN AGRICULTURE has not been arranged for the coming autumn. The work in Entomology offered last fall consisted of a course of lectures on Economic Entomology and a laboratory course on Scale Insects. A special announcement can be had upon application next August.

The REGULAR SESSION work is as follows:

4A. *Agriculture*. The insects affecting field crops are discussed in connection with their cultivation.

4B. *Horticulture*. The insects affecting the various fruit crops are discussed as each fruit is considered.

5D. *Viticulture*. The insect pests of the vine are fully treated of in this course.

7A. *General Entomology*. A rapid review of the classification, structure, and habits of insects.

7B. *Economic Entomology*. Review of the insects most injurious to agriculture in California.

7C. *Ecology*. The relation of insects to their environment. A dis-

cussion of the newer lines of thought concerning the evolution of insects.

7D. *Apiculture*. Practical review of the methods and problems of modern bee keeping.

8A. *Morphology of Insects*. A laboratory study of insect structure, including careful drawing and dissection of a series of typical insects.

8B. *Scale Insects*. Detailed study of the structure and classification of scale insects, and the methods of using the compound microscope.

8C. *Entomotaxy*. The methods of collecting, mounting, and determining insects.

8D. *Apiary Work*. Actual handling of bees under apiary conditions, and experiments with bees in observation hives.

9B. *Insecticides and Fungicides*. The composition and compounding of remedies.

9C. *Spraying*. A study of the methods of spraying plants for the control of insect pests and fungous diseases.

11A. *Ontogeny of Insects*. A detailed study of the genesis of the insect structure.

11B. *Phylogeny of Insects*. The genealogy of insects and the study of classification in the light of evolution.

12. *Advanced Laboratory Work*. Each term a different line of advanced study will be offered in this course, and individual work will be arranged for those desiring to begin research work.

23A. *Entomological Literature*. A seminary course for conference between students engaged in bibliographical study.

23B. *Laboratory Conference*. A seminary course prescribed for all students taking Courses 12 or 24, designed for mutual assistance in the work under way in the laboratory.

24. *Research Work*. Individual investigation under the direct supervision of the instructor, but not necessarily at Berkeley nor in term time. Credit will only be given on the basis of work ready for publication.

UNIVERSITY EXTENSION IN AGRICULTURE.

The Department of University Extension in Agriculture has heretofore confined itself to Farmers' Institutes. With this publication it begins work of a somewhat wider scope. The College of Agriculture and the Agricultural Experiment Station have from the beginning striven to serve the people in every part of the State, and, while providing laboratories at Berkeley for the study of agricultural problems, and class rooms where the young people of the State may come for instruction, they have also endeavored to extend their influences into every community. These efforts may be grouped into the following classes:

1. *Correspondence* with individuals in answer to requests for information on agricultural problems.
2. *Publications*, based on studies made by members of the Station staff. These are sent free of charge to residents of the State applying therefor.
3. *Lectures* before public meetings: Farmers' Institutes, or other gatherings representing agricultural interests.
4. *Reading Courses*, like that outlined in the present circular.
5. *Personal Visits* by members of the staff to regions where problems of great importance arise.
6. *Coöperative Experiments*, conducted by individuals, working under the advice and generally the personal supervision of a member of the Station staff.
7. *Investigations*, involving the residence for some time of a representative of the University in the locality where the problem in hand may be best solved.
8. *Substations*, which are established in regions where there is a variety of problems, requiring years for their solution, making a rather permanent equipment necessary and the continuous residence of a Station man.

To this list should be added the increasing number of graduates of the Agricultural College, who are farming in many parts of the State, and who should be and who are centers of influence for University ideals.

The location of the College and Station at Berkeley has been fortunate in that it favored the development and this broad conception of their opportunities and duties toward the State at large.